Other Documents in the
Preparing for Tomorrow's High Tide Series

A Progress Report of the
Delaware Sea Level Rise Advisory Committee
(November 2011)

Delaware Sea Level Rise Vulnerability Assessment
for the State of Delaware
(July 2012)
Preparing for Tomorrow’s High Tide

A Mapping Appendix to the Delaware Sea Level Rise Vulnerability Assessment

Prepared for the Delaware Sea Level Rise Advisory Committee by the Delaware Coastal Programs of the Department of Natural Resources and Environmental Control
About This Document

This Map Appendix was developed and produced by the DNREC Delaware Coastal Programs for use by the Delaware Sea Level Rise Advisory Committee. It contains background information about sea level rise, the sea level rise vulnerability assessment, and maps depicting the exposure of thirty-nine resources to sea level rise under three scenarios. This Appendix is intended to be used in concert with the Delaware Sea Level Rise Vulnerability Assessment Document, which contains detailed descriptions of each mapped resource and their vulnerability to sea level rise.

Users of this document should carefully read the introductory materials included to understand the assumptions and trade-offs that were made in order to depict this information at a statewide scale.

These maps are a representation of inundation based on local Mean Higher High Water (MHHW). Inundation is assumed to occur at a constant elevation (Bathtub Model) and no other factors other than tidal elevation are used to determine water levels.

The land surface elevations are based on data with an average accuracy of 15 cm (6 inches); however areas of heavy vegetation may have errors exceeding that amount.

The Delaware Coastal Programs makes no warranty and promotes no other use of these maps other than as a preliminary planning tool.

This project was funded by the Delaware Department of Natural Resources and Environmental Control, in part, through a grant from the Delaware Coastal Programs with funding from the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administrations, under award number NA10NOS4190202.

Further information about this document and the Delaware Sea Level Rise Advisory Committee can be found online at http://de.gov/slradvisorycommittee and at the address below:

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Contents

DELAWARE IS A COASTAL STATE ........................................................................................................ 1
FUTURE SEA LEVELS ......................................................................................................................... 2
DETAILED METHODOLOGY .............................................................................................................. 3
CREATION OF BATHTUB INUNDATION MODEL .............................................................................. 3
PROCEDURE FOR DEVELOPING INUNDATION MAPS ....................................................................... 4
IDENTIFYING AND COLLECTING RESOURCE DATA ......................................................................... 5
PROCESSING VULNERABILITY DATA IN GIS .................................................................................... 6
SCALING DATA: DISPLAYING INFORMATION FOR DIFFERENT USES ............................................. 7
DATA TYPES USED IN VULNERABILITY MAPPING ......................................................................... 9
HOW MAPS ARE PRESENTED IN THIS DOCUMENT ...................................................................... 11
GRIDS ............................................................................................................................................. 11
POINTS .......................................................................................................................................... 11
INDIVIDUAL AREAS .......................................................................................................................... 12
NATURAL RESOURCES .................................................................................................................... 14
SOCIETY & ECONOMY ..................................................................................................................... 44
PUBLIC SAFETY & INFRASTRUCTURE ............................................................................................. 64

Tables

TABLE 1 - MHHW, BY WATERSHED, AS CALCULATED BY VDATUM ............................................ 4
TABLE 2 - SUMMARY OF GIS LAYERS USED IN THE VULNERABILITY ASSESSMENT ................ 5

Figures

FIGURE 1 - BATHTUB MODEL OF SEA LEVEL RISE ....................................................................... 3
FIGURE 2 - COMPARISON OF BATHTUB (SINGLE VALUE) MODEL VS. A MODELED WATER SURFACE ... 3
FIGURE 3 - EXAMPLE SEGMENT FROM ARCGIS MODELBuilder. CLIPPING DATA TO SCENARIOS IN KENT COUNTY 6
FIGURE 4 - EXAMPLE DATA TABLE ............................................................................................... 6

Maps

MAP 1 - TIDAL WETLANDS ............................................................................................................. 15
MAP 2 - TIDAL WETLANDS ........................................................................................................... 16
MAP 3 - TIDAL WETLANDS .......................................................................................................... 17
MAP 4 - NON-TIDAL WETLANDS .................................................................................................. 18
MAP 5 - NON-TIDAL WETLANDS .................................................................................................. 19
MAP 6 - NON-TIDAL WETLANDS .................................................................................................. 20
MAP 7 - COASTAL IMPOUNDMENTS ............................................................................................ 21
MAP 8 - COASTAL IMPOUNDMENTS ............................................................................................ 22
MAP 9 - COASTAL IMPOUNDMENTS ............................................................................................ 23
MAP 10 - HABITATS OF CONSERVATION CONCERN .................................................................. 24
MAP 11 - HABITATS OF CONSERVATION CONCERN .................................................................. 25
MAP 12 - HABITATS OF CONSERVATION CONCERN .................................................................. 26
MAP 13 - FORESTED LAND ........................................................................................................... 27
MAP 14 - FORESTED LAND ........................................................................................................... 28
## Contents

Maps (continued)

<table>
<thead>
<tr>
<th>Map</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAP 15</td>
<td>FORESTED LAND</td>
<td>29</td>
</tr>
<tr>
<td>MAP 16</td>
<td>PROTECTED LANDS</td>
<td>30</td>
</tr>
<tr>
<td>MAP 17</td>
<td>PROTECTED LANDS</td>
<td>31</td>
</tr>
<tr>
<td>MAP 18</td>
<td>PROTECTED LANDS</td>
<td>32</td>
</tr>
<tr>
<td>MAP 19</td>
<td>NATURE PRESERVES</td>
<td>33</td>
</tr>
<tr>
<td>MAP 20</td>
<td>HIGHLY PRODUCTIVE SOILS</td>
<td>34</td>
</tr>
<tr>
<td>MAP 21</td>
<td>HIGHLY PRODUCTIVE SOILS</td>
<td>35</td>
</tr>
<tr>
<td>MAP 22</td>
<td>HIGHLY PRODUCTIVE SOILS</td>
<td>36</td>
</tr>
<tr>
<td>MAP 23</td>
<td>AGRICULTURE CONSERVATION EASEMENTS</td>
<td>37</td>
</tr>
<tr>
<td>MAP 24</td>
<td>AGRICULTURE CONSERVATION EASEMENTS</td>
<td>38</td>
</tr>
<tr>
<td>MAP 25</td>
<td>AGRICULTURE CONSERVATION EASEMENTS</td>
<td>39</td>
</tr>
<tr>
<td>MAP 26</td>
<td>AGRICULTURAL PRESERVATION DISTRICTS</td>
<td>40</td>
</tr>
<tr>
<td>MAP 27</td>
<td>AGRICULTURAL PRESERVATION DISTRICTS</td>
<td>41</td>
</tr>
<tr>
<td>MAP 28</td>
<td>AGRICULTURAL PRESERVATION DISTRICTS</td>
<td>42</td>
</tr>
<tr>
<td>MAP 29</td>
<td>COMMERCIAL BUSINESS LICENSES</td>
<td>45</td>
</tr>
<tr>
<td>MAP 30</td>
<td>COMMERCIAL BUSINESS LICENSES</td>
<td>46</td>
</tr>
<tr>
<td>MAP 31</td>
<td>COMMERCIAL BUSINESS LICENSES</td>
<td>47</td>
</tr>
<tr>
<td>MAP 32</td>
<td>TRI REPORTERS</td>
<td>48</td>
</tr>
<tr>
<td>MAP 33</td>
<td>RESIDENTIAL ADDRESSES</td>
<td>49</td>
</tr>
<tr>
<td>MAP 34</td>
<td>RESIDENTIAL ADDRESSES</td>
<td>50</td>
</tr>
<tr>
<td>MAP 35</td>
<td>RESIDENTIAL ADDRESSES</td>
<td>51</td>
</tr>
<tr>
<td>MAP 36</td>
<td>FUTURE DEVELOPMENT AREAS</td>
<td>52</td>
</tr>
<tr>
<td>MAP 37</td>
<td>FUTURE DEVELOPMENT AREAS</td>
<td>53</td>
</tr>
<tr>
<td>MAP 38</td>
<td>FUTURE DEVELOPMENT AREAS</td>
<td>54</td>
</tr>
<tr>
<td>MAP 39</td>
<td>ACTIVE AGRICULTURAL LAND</td>
<td>55</td>
</tr>
<tr>
<td>MAP 40</td>
<td>ACTIVE AGRICULTURAL LAND</td>
<td>56</td>
</tr>
<tr>
<td>MAP 41</td>
<td>ACTIVE AGRICULTURAL LAND</td>
<td>57</td>
</tr>
<tr>
<td>MAP 42</td>
<td>DELAWARE STATE PARKS</td>
<td>58</td>
</tr>
<tr>
<td>MAP 43</td>
<td>NATIONAL HISTORIC REGISTER SITES</td>
<td>59</td>
</tr>
<tr>
<td>MAP 44</td>
<td>STATE HISTORIC SITES</td>
<td>60</td>
</tr>
<tr>
<td>MAP 45</td>
<td>STATE HISTORIC SITES</td>
<td>61</td>
</tr>
<tr>
<td>MAP 46</td>
<td>STATE HISTORIC SITES</td>
<td>62</td>
</tr>
<tr>
<td>MAP 47</td>
<td>DAMS AND DIKES</td>
<td>65</td>
</tr>
<tr>
<td>MAP 48</td>
<td>DAMS AND DIKES</td>
<td>66</td>
</tr>
<tr>
<td>MAP 49</td>
<td>DAMS AND DIKES</td>
<td>67</td>
</tr>
<tr>
<td>MAP 50</td>
<td>FIRE AND EMS SERVICES</td>
<td>68</td>
</tr>
<tr>
<td>MAP 51</td>
<td>POLICE STATIONS</td>
<td>69</td>
</tr>
<tr>
<td>Maps (continued)</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>MAP 52 - EMERGENCY OPERATIONS AND 911 CENTERS</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>MAP 53 - EVACUATION ROUTES</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>MAP 54 - EVACUATION ROUTES</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>MAP 55 - EVACUATION ROUTES</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>MAP 56 - DART BUS ROUTES</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>MAP 57 - DART BUS ROUTES</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>MAP 58 - DART BUS ROUTES</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>MAP 59 - DART BUS STOPS</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>MAP 60 - RAILROADS</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>MAP 61 - RAILROADS</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>MAP 62 - RAILROADS</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>MAP 63 - BOAT RAMPS</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>MAP 64 - ROADS</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>MAP 65 - ROADS</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>MAP 66 - ROADS</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>MAP 67 - SEPTIC SYSTEMS</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>MAP 68 - SEPTIC SYSTEMS</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>MAP 69 - SEPTIC SYSTEMS</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>MAP 70 - SEWER PUMPING STATIONS</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>MAP 71 - SEWER PUMPING STATIONS</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>MAP 72 - SEWER PUMPING STATIONS</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>MAP 73 - PUBLIC WASTEWATER FACILITIES</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>MAP 74 - WATER SUPPLY WELLS</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>MAP 75 - DOMESTIC WATER SUPPLY</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>MAP 76 - DOMESTIC WATER SUPPLY</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>MAP 77 - DOMESTIC WATER SUPPLY</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>MAP 78 - BROWNFIELD SITES</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>MAP 79 - LANDFILLS</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>MAP 80 - SALVAGE YARDS</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>MAP 81 - LEAKING UNDERGROUND STORAGE TANKS</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>MAP 82 - UNDERGROUND STORAGE TANKS</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>MAP 83 - UNDERGROUND STORAGE TANKS</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td>MAP 84 - UNDERGROUND STORAGE TANKS</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>MAP 85 - CONTAMINATED SITES</td>
<td>103</td>
<td></td>
</tr>
<tr>
<td>MAP 86 - CONTAMINATED SITES</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>MAP 87 - CONTAMINATED SITES</td>
<td>105</td>
<td></td>
</tr>
</tbody>
</table>
Delaware is a Coastal State

Its economy and quality of life have historically been linked to its shores, its vast expanses of protected tidal wetlands and its fertile farm fields. Because of its location and dependence on the coast, Delaware is particularly vulnerable to the effects of rising sea levels.

The line between land and sea along Delaware’s coast is constantly on the move. It is obvious to those who live near or spend time on the water that the high tide line along Delaware’s shorelines fluctuates daily depending on local weather and the cycle of the moon. Less obvious is that fact that the high tide line is slowly and steadily moving landward and upward\(^1\).

Tide data has been collected at Lewes for ninety years and at Reedy Point (located near the C&D Canal) for fifty years. These data sets have given scientists consistent long-term tidal records to track tidal fluctuation and sea level changes in the ocean and bays. The tide data show that the mean sea level in Delaware has risen about a foot over the last century. Other long-term tide stations within the Mid-Atlantic region show similar trends\(^2\).

Globally, sea level rises for two main reasons: warming water and loss of ice on land. As the ocean absorbs solar radiation, the water warms. When water warms, it expands and causes the mean level of the water to rise. In addition, as the Earth becomes warmer, land-based glaciers and icecaps melt. This meltwater empties into oceans and increases mean sea levels worldwide. The worldwide average rate of sea level rise during the twentieth century, as determined by tide gauge measurements, was about 0.07 inches per year (or about 7 inches over 100 years).\(^3\)

Tide gauges indicate that Delaware’s local sea level is rising faster than the worldwide average. The rate of sea level rise recorded at the tide gauge in Lewes is 0.13 inches per year (or 13 inches over 100 years)\(^4\), as compared to the worldwide average rate of 0.07 inches per year. The difference between the local rate and the global rate is due to the vertical movement of the Earth’s crust, which is causing the land in Delaware to slowly sink. Tide gauges used to track sea level record the combined motion of the land and the sea.


\(^2\)Tide gauge information is available from the National Oceanic and Atmospheric Administration: http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml


\(^4\)Tide gauge information is available from the National Oceanic and Atmospheric Administration: http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml.
Future Sea Levels

While it cannot be proven with certainty, climatologists have predicted that the rate of sea level rise occurring today will likely become greater in the decades to come. If this occurs, it will affect homes, businesses, roads, natural areas and other important resources. Many federal, state and local officials have decided that it is prudent to begin planning now for the effects of rising sea levels.

In 2009, the Delaware Department of Natural Resources and Environmental Control (DNREC) formed a Sea Level Rise Technical Workgroup to provide planning scenarios for sea level rise up to the year 2100. This workgroup, composed of scientists from the University of Delaware, Delaware Geological Survey, Center for the Inland Bays, Partnership for the Delaware Estuary and DNREC, reviewed historical data for local sea level rise and reviewed the findings of international and national expert panels. Based on this information, the Sea Level Rise Technical Workgroup recommended three planning scenarios. The conclusions of the workgroup were then reviewed by several national experts. The Committee chose to recommend a range of scenarios because it is not possible to precisely predict future rates of sea level rise. These scenarios can be used for understanding and planning for sea level rise.

![DNREC Sea Level Rise Scenarios](image)

The Technical Workgroup’s lowest scenario was a sea level rise of 1.6 feet (0.5 meters) between now and the year 2100. This scenario is slightly higher than the current rate of sea level rise in Delaware and is partially based on low estimates for future global warming. The highest scenario was a sea level rise of 4.9 feet (1.5 meters) between now and the year 2100. This scenario is based on higher estimates of future global warming. The middle scenario was 3.3 feet (1.0 meter) between now and the year 2100, and is based on moderate estimates of future global warming.

From these planning scenarios, a series of maps was developed using very accurate elevation data. These maps show the areas that could be flooded (or inundated) for each planning scenario. The inundation maps were used by the Sea Level Rise Advisory Committee to complete this Vulnerability Assessment. The inundation maps are available through an online viewer at: http://de.gov/slmap

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Future Sea Level

DETAILED METHODOLOGY

The sea level rise vulnerability assessment maps were designed to provide at-a-glance information on extent and density of inundation impacts for Sea Level Rise Advisory Committee members and interested citizens. For interested readers, the following provides an in-depth, technical explanation of the steps and methods used.

CREATION OF BATHTUB INUNDATION MODEL

A statewide bathtub inundation model was created by the Delaware Coastal Programs in support of DNREC’s internal sea level rise policy. This bathtub model uses only two variables, the inundation level (in this case, the sea level rise scenarios) and the ground elevation, derived from a lidar-based digital elevation model (DEM). The land surface elevations derived from lidar data have a statewide average root mean square error (RMSE) of 18 cm (6 inches) however; areas of heavy vegetation may have elevation errors exceeding that amount.

In the bathtub model, we assume that the tidal range will remain constant with SLR, thus the MHHW levels will increase at the same rate as sea level rise. This is a simplification. Increasing water depth and fetch length may increase the amplitude of MHHW.

In simple terms, any land with an elevation lower than the sea level rise scenario is assumed to be inundated (Figure 1). However, impoundments and other areas protected by dikes or dams are assumed to protect the inland areas from tidal inundation until the water level exceeds the lowest dike elevation, at which time all land area behind the dike is assumed to become inundated. Bridges are shown at true elevation; if the bridge is shown as inundated on the bathtub map, the water level has exceeded the road surface of the bridge.

Bathtub models are limited in that they do not account for the complex natural and human processes (erosion, tidal forcing, sediment accretion and shoreline protection structures) that may accompany rising sea levels, but do provide a readily available and understandable planning tool capable of estimating the magnitude of potential impacts. Figure 2 compares bathtub models to hydrodynamic models.

<table>
<thead>
<tr>
<th>Data Readily Available</th>
<th>Modeled Water Surface</th>
<th>Single Value Water Surface</th>
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<tbody>
<tr>
<td></td>
<td>sometimes</td>
<td>✓</td>
</tr>
<tr>
<td>Quickly Create Multiple Scenarios</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>Accounts for Hydrodynamics of Water Rise</td>
<td>✓</td>
<td>×</td>
</tr>
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</table>

Figure 2 - Comparison of bathtub (Single Value) model vs. a modeled water surface.
PROCEDURE FOR DEVELOPING INUNDATION MAPS

1. Lidar data was converted to a more usable format using raster math to convert meters to centimeters.

2. Target watershed boundaries were extended into receiving water body and lidar data was extracted for the target watershed.

3. Mean Higher High Water (MHHW) elevations were determined for each watershed in the state using NOAA VDatum software\(^6\). (Table 1)

   [The watershed reference location for MHHW is at the confluence of the selected watershed’s river and the Delaware Bay/River, except for the Inland Bays, Nanticoke River, and Atlantic Ocean. In the Inland Bays, the location of MHHW is the center of the selected bay. In the Nanticoke River, the location of MHHW is the city of Seaford, and in the developed Atlantic Coast, the location is offshore in the Atlantic Ocean near Indian River Inlet.]

4. To create the scenario layers the elevation data was reclassified into the number of target elevations (i.e scenarios) plus 1.

   Example: Lowest number in data to MHHW = 0, MHHW+1 to first target number = 2, last target number +1 to highest number in data = No Data. (Spatial Analyst/Reclassify/Reclassify)

5. Data was converted to polygons for each of the target elevations.

6. County-based layers were created by first splitting watersheds that border counties. Then all the watersheds for each county were combined into one layer.

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\(^6\)NOAA's VDatum software is also used to link elevations with differing datums. This allows the MHHW references to be tied to the lidar land elevations based on NAVD88.
IDENTIFYING AND COLLECTING RESOURCE DATA

The Sea Level Rise Advisory Committee Society & Economy, Natural Resources and Public Safety & Infrastructure workgroups identified 140 resources they wished to analyze for the Vulnerability Assessment. Due to the large number of resources of concern, the best available existing data was used for the assessment as time and staff resources would not permit the creation or enhancement of any new datasets. These existing datasets were used "as-is". Staff involved in the assessment attempted to ensure that the datasets were reasonably accurate; however the Delaware Coastal Programs and the Delaware Sea Level Rise Committee make no guarantees as to the accuracy of the data utilized in this assessment.

Of the 140 resource data layers requested, 75 were analyzed during the course of the vulnerability assessment. Thirty-six layers did not exist, were not reasonable accurate, were never received from the source or were classified and unable to be utilized in a public document. Twenty-five of the data requests required more study or research to develop and use.

Table 2 shows the number of data layers identified and used as part of the vulnerability assessment.

Data availability for a statewide assessment was a significant challenge for this initiative. While some data layers were easily identified and located, others were much more difficult to find, in large part because there is no centralized data location system for the state or its executive branch departments. Once found, most of this data lacked information regarding the methods used to collect it and date of last update. The largest hurdles for data collection included:

- No central, statewide listing or searchable index of data layers
- No one person/agency to contact for data information
- Agency data residing in only in hardcopy reports
- Private sector or proprietary data not available for public use
- Privacy concerns
- Homeland security restrictions

Privacy concerns and homeland security restrictions were able to be addressed so the data could be utilized. Census and housing data was summarized to the Block Group level to avoid singling out individuals that could potentially be identified through mapping community data. Other sensitive data, such as individual residential wells, were summarized on a scale per mile grid or displayed at a scale that would eliminate singling out one location. In some cases (i.e. pipeline data) the data simply was not mapped due to homeland security restrictions and vulnerability data is provided in table form only.

*Workgroup Vulnerability Data Lists.xlsx
PROCESSING VULNERABILITY DATA IN GIS

Analysis of each data layer followed a similar process, outlined below. As much as possible, tools available in ArcGIS were used to automate analysis and provide consistency among the five analysts performing the work.

1. Aggregate or split data by county
2. Create county-level impacts for each scenario – see Model Builder diagram below.
3. Summarize into Excel spreadsheet – lots of cutting and pasting

Unfortunately, there was no automated way to transfer the data summarized from the attribute table of the data layer into an Excel Spreadsheet. As such, there were lots of manual copy and paste operations. The result, however, was a very useful, condensed data table for each resource analyzed. These data tables are available in the main body of the Sea Level Rise Vulnerability Assessment.

**Figure 3** - Example segment from ArcGIS ModelBuilder, clipping data to scenarios in Kent County

**Figure 4** - Example data table.

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<th>1.0 m</th>
<th>1.5 m</th>
<th>0.5 m</th>
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<td>168,384</td>
<td>61,989</td>
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<td>42%</td>
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<td>New Castle</td>
<td>45,553</td>
<td>11,407</td>
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<td>13,428</td>
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<td>28%</td>
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<td>Kent</td>
<td>54,399</td>
<td>30,289</td>
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<td>Sussex</td>
<td>68,433</td>
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<td>24,837</td>
<td>30%</td>
<td>34%</td>
<td>36%</td>
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**Source:** DNREC - Parks and Recreation, Outdoor Recreation Inventory (2009), unpublished
Scaling Data: Displaying Information for Different Uses

Some datasets developed for the Sea Level Rise Advisory Committee contain hundreds or thousands of individual point locations for a resource; others may contain numerous tracts of land. In order to display this volume of information at a statewide scale, the data is converted into “grid” maps where 1 grid = 1 mi². Using a color coded scale, the grids display either the total number of locations or acres affected within that square mile. At a glance, this allows viewers to see the degree to which a particular resource is affected by sea level rise in relation to other areas within the State.

State
1 grid = 1 square mile

Statewide maps allow for the identification of regions of concern and areas where more detailed study would be required. These maps also show the overall impact of sea level rise on the State’s resources.

For smaller areas of interest, decreasing the grid size will more precisely show the areas affected by sea level rise.
Local

Non-gidded Data

Local maps may include aerial photography to precisely show locations. These maps are used to identify individual points or tracts of land to determine how much of a certain tract might be affected.

County

1 grid = 1/16th square mile

County maps could be used by those needing more specific information, but not necessarily exact locations. Acreages or total numbers of points in the area can still be easily determined.

At the local level, the area of interest is usually small enough that the actual locations or tracts of land can be displayed.
Data Types Used in Vulnerability Mapping

Maps were developed to visually show where resources could be inundated by sea level rise. Each map contains data shown as one of three types: point, line, and polygon. Geographic data is almost always depicted in one of these forms.

**POINT**

A point is an object that has a specific location on a map. Examples: Historic Sites, Septic Systems, Fire Stations

- 145 points
  - Can be easily viewed at the state level

- 78,109 points
  - Cannot be easily viewed at the state level

Convert to Grid

A grid map, which counts points within a square mile, is a better way to visualize inundation impacts for resources at the state level with a large number of points.
**POLYGON**

A polygon is an enclosed feature with at least three sides. Examples: Wetlands and Parcels of Land.

![Tidal Wetlands Map](image1)

Small polygons cannot be seen on state-wide maps.

![Tidal Wetlands Map](image2)

A grid map allows small polygons to be summed, which makes impacts visible.

**LINE**

A line is a feature which only has length and no width. The feature has a beginning and an end. Examples: Roads, Evacuation Routes, Railroads.

![Roads Map](image3)

At the state level, small impacted line segments cannot be easily seen.

![Roads Map](image4)

Impacts to line segments become more detailed and easier to see as the map area becomes more localized.
How Maps are Presented in this Document

**GRIDS**

Point and polygon data, as shown on the previous page, may be difficult to see if there are many points or there are many small or thinly shaped polygons. To make the information easier to see, maps here are shown with this type of data as a grid.

In the example to the right, is a Grid Map of Tidal Wetlands impacted by the 1.0 meter Scenario. Because the impacts form thin, narrow bands as polygons. The data was converted to a 1 square mile grid system.

Through GIS analysis, the wetland polygons within each 1 mile square are counted and summed together. This illustrates acres of impacted wetlands per square mile. Similarly, for maps with many points that will be affected, GIS is used to count the number of points inside each box. The boxes are then color coded to indicate how many points are inside.

The legend breaks the data into four groups using the Natural Breaks (see ESRI ArcGIS documentation). Data for each resource is classified starting with the 1.5 meter scenario. This forms the upper bound and the legend is then applied to the other scenarios. Applying the legend this way allows the reader to see the trend of the impact as the scenarios progress. Exposure is shown in shades of purple; the darker the color, the greater the impact in that square mile box. Creation of the legend classifications is repeated for each resource so while the number values are comparable between scenarios for a given resource, only the magnitude of impact is comparable between resources.

**POINTS**

For some point data layers, there are only a few points in the entire State (e.g. Sewage treatment plants). In these cases the individual points are shown on the map and the points are color coded to show which SLR scenario affects them first.

Green – point is first affected by the 0.5 meter SLR Scenario  
Yellow – point is first affected by the 1.0 meter SLR Scenario  
Red – point is first affected by the 1.5 meter SLR Scenario  
Grey – these points are not impacted by any of the 3 Scenarios

So, a green point will be inundated during the 0.5; 1.0; and 1.5 meter scenarios. A red point is only inundated at the 1.5 meter scenario.
**INDIVIDUAL AREAS**

Some data layers are based on polygons, but there are only a few polygons throughout the state. In these cases, there are not enough to create the grids, as above. However, we still want to show how each of those polygons, individually, is affected by sea level rise. This is the case for resources like State Parks or Nature Preserves where we want to know how much of a specific area is affected under each of the scenarios.

Pie Chart symbols are used to illustrate percentage of impact.

Pie charts are useful for illustrating how individual parts contribute to an overall whole set. For clarity, it is best if there are only a few categories to display. 4 categories are used for this application.

![Pie Chart](image)

Each pie represents the total area of interest, say a Nature Preserve. Each colored slice of the pie is that portion of the whole affected with each scenario. The remaining grey portion is that portion not exposed to impacts from sea level rise.
Natural Resources
Map 1
Wetlands in the 2010 SWMP dataset classified as either marine, estuarine, or riverine wetlands and other wetlands types having a 'tidal' modifier.
Map 2
Wetlands in the 2010 SWMP dataset classified as either marine, estuarine, or riverine wetlands and other wetland types having a "tidal" modifier.
Tidal Wetlands

Within
1.5 meter Scenario

Legend
Tidal Wetlands
Acres per sq mi
- 0 - 75
- 76 - 200
- 201 - 400
- 401 - 585

Counties Boundaries
Major Roads
Municipalities

Map 3
Wetlands in the 2010 SWMP dataset classified as either marine, estuarine, orinverse wetlands and other wetlands types having a 'tidal' modifier.
Map 4: Non-Tidal Wetlands

Legend

Wetlands
Acres per sq mi
- 1 - 20
- 21 - 75
- 76 - 200
- 201 - 460

County Boundary
Major Road
Municipalities

Non-Tidal Wetlands

Within
0.5 meter Scenario

Wetlands from the 2010 SWMP Update that are not classified as "tidal" from the previous resource map.
Map 5

Wetlands from the 2010 SWMP Update that are not classified as "tidal" from the previous resource map.
Non-Tidal Wetlands

Within 1.5 meter Scenario

Legend

Wetlands
Acres per sq mi

1 - 20
21 - 75
76 - 200
201 - 460

County Boundary
Major Road
Municipalities

Map 6

Wetlands from the 2010 SWMP Update that are not classified as “tidal” from the previous resource map.
Map 7
Areas along the coast fronted by a dike, tide gate, or other water control structure either for flood control or wildlife management.
Coastal Impoundments

Within 1.0 meter Scenario

Legend
Impoundments
Acres per sq mi
- 1 - 60
- 61 - 180
- 181 - 380
- 381 - 635

County Boundary
Major Road
Municipalities

Map 8
Areas along the coast fronted by a dike, tide gate, or other water control structure either for flood control or wildlife management.

Source: Delaware Coastal Programs, Impoundments (2010), unpublished.
Coastal Impoundments
Within 1.5 meter Scenario

Legend
Impoundments
Acres per sq mi
- 1 - 60
- 61 - 180
- 181 - 380
- 381 - 635

County Boundary
Major Road
Municipalities

Map 9
Areas along the coast fronted by a dike, tide gate, or other water control structure either for flood control or wildlife management.
Habitats of Conservation Concern
Within 0.5 meter Scenario

Legend
Habitat of Conservation Concern
Acres per sq mi
- < 50
- 50 - 100
- 100 - 200
- 200 - 500

County Boundary
Major Road
Municipalities

Map 10
Habitats that are unique or rare as defined by the Natural Heritage Program.
Habitats of Conservation Concern
Within 1.0 meter Scenario

Legend
Habitat of Conservation Concern
Acres per sq mi
- < 50
- 50 - 100
- 100 - 200
- 200 - 500

County Boundary
Major Road
Municipalities

Map 11
Habitats that are unique or rare as defined by the Natural Heritage Program.
Habitats of Conservation Concern
Within 1.5 meter Scenario

Legend
Habitat of Conservation Concern
Acres per sq mi
- < 50
- 50 - 100
- 100 - 200
- 200 - 500

County Boundary
Major Road
Municipalities

Map 12
Habitats that are unique or rare as defined by the Natural Heritage Program.
Map 13
Lands classified as forested (400 series) in the Land Use/Land Cover dataset.
Forested Land

Within 1.0 meter Scenario

Legend
Forest
Acres per sq mi
- 1 - 15
- 16 - 35
- 36 - 70
- 71 - 210

County Boundary
Major Road
Municipalities

Map 14
Lands classified as forested (400 series) in the Land Use/Land Cover dataset.
Map 15
Lands classified as forested (400 series) in the Land Use/Land Cover dataset.
Map 16
List of protected land and public parks managed by federal, state, county, and municipal governments, and private conservation groups.
Protected Lands

Within 1.0 meter Scenario

Legend
Protected Lands
Acres per sq mi
- 0 - 90
- 91 - 250
- 251 - 450
- 451 - 640
- County Boundary
- Major Road
- Municipalities

Map 17
List of protected land and public parks managed by federal, state, county, and municipal governments, and private conservation groups.
Protected Lands

Within
1.5 meter Scenario

Legend
Protected Lands
Acres per sq mi
0 - 90
91 - 250
251 - 450
451 - 640

County Boundary
Major Road
Municipalities

Map 18
List of protected land and public parks managed by federal, state, county, and municipal governments, and private conservation groups.
Map 19

Are Natural Areas (defined in 7 Del. Code, §9202) that are registered with the Division of Parks and Recreation.
Highly Productive Soils

Within 0.5 meter Scenario

Legend
Highly Productive Soils
Acres per sq mi
- 1 - 40
- 41 - 100
- 101 - 250
- 251 - 500

County Boundary
Major Road
Municipalities

Map 20
Soils classified as "Highly Productive for Agriculture" by the Natural Resources Conservation Service.
Map 21
Soils classified as "Highly Productive for Agriculture" by the Natural Resources Conservation Service.
Highly Productive Soils
Within 1.5 meter Scenario

Legend
Highly Productive Soils
Acres per sq mi
1 - 40
41 - 100
101 - 250
251 - 500
County Boundary
Major Road
Municipalities

Map 22
Soils classified as “Highly Productive for Agriculture” by the Natural Resources Conservation Service.
Map 23
Lands listed with the Delaware Department of Agriculture as having an easement permanently restricting development on the property.
Lands listed with the Delaware Department of Agriculture as having an easement permanently restricting development on the property.
Agricultural Conservation Easements Within 1.5 meter Scenario

Legend
Easements
Acres per sq mi
1 - 30
31 - 105
106 - 215
216 - 540
County Boundary
Major Road
Municipalities

Map 25
Lands listed with the Delaware Department of Agriculture as having an easement permanently restricting development on the property.

Source: Del. Dept. of Agriculture, State Ag Easements, 2010-09-17
Agricultural Preservation Districts
Within 0.5 meter Scenario

Legend
Districts
Acres per sq mi
1 - 45
46 - 140
141 - 320
321 - 570
County Boundary
Major Road
Municipalities

Map 26
Land devoted to agricultural use and enrolled in a voluntary program not to develop for 10 years.
Map 27
Land devoted to agricultural use and enrolled in a voluntary program not to develop for 10 years.
Agricultural Preservation Districts
Within 1.5 meter Scenario

Legend
Districts
Acres per sq ml
1 - 45
46 - 140
141 - 320
321 - 570

County Boundary
Major Road
Municipalities

Map 28
Land devoted to agricultural use and enrolled in a voluntary program not to develop for 10 years.
Society and Economy
Map 31
Addresses from the state business license database geocoded by the Center for Applied Demography and Survey Research.
Facilities generating amounts of toxic industrial chemicals required to be reported under the Toxic Release Inventory. This is a proxy for Industrial and Manufacturing Facilities.
Map 33
Address points extracted from county WIT databases, and geo-coded by the Center for Applied Demography and Survey Research.
Residential Addresses

Within 1.0 meter Scenario

Legend
Residential Addresses per sq mi
- 1 - 50
- 51 - 185
- 186 - 430
- 431 - 1260
County Boundary
Major Road
Municipalities

Map 34
Address points extracted from county 911 databases and geo-coded by the Center for Applied Demography and Survey Research.

Source: University of Delaware CADSR 9-1-1 Address Database
Residential Addresses

Within 1.5 meter Scenario

Legend
Residential Addresses per sq ml
- 1 - 50
- 51 - 185
- 186 - 430
- 431 - 1260

County Boundary
Major Road
Municipalities

Map 35
Address points extracted from county 911 databases and geo-coded by the Center for Applied Demography and Survey Research.
Strategies for State Spending 2010
Impacts to Level 3 Investment Areas
0.5 m SLR

Legend
Acres
< 25
25 - 75
75 - 125
125 - 325
County Boundary
Major Road
Municipalities

Level 3:
Future Development Areas, or areas that are planned for development in the long-term, but are not currently targeted for state investments for schools, roads and other infrastructure.

Map 36
Areas for 'Future Development' represented by Level 3 Investment Areas, Strategies for State Spending.

Source: Delaware Office of State Planning Coordination, Investment Levels, Delaware State Strategies for State Policies and Spending (2010), 2010-10-01
Strategies for State Spending 2010
Impacts to Level 3 Investment Areas 1.0 m SLR

Legend
Acres
- < 25
- 25 - 75
- 75 - 125
- 125 - 325

County Boundary
Major Road
Municipalities

Level 3:
Future Development Areas, or areas that are planned for development in the long term, but are not currently targeted for state investments for schools, roads and other infrastructure.

Map 37
Areas for 'Future Development' represented by Level 3 Investment Areas, Strategies for State Spending.
Strategies for State Spending 2010
Impacts to Level 3 Investment Areas 1.5 m SLR

Legend
Acres
- < 25
- 25 - 75
- 75 - 125
- 125 - 325

County Boundary
- Major Road
- Municipalities

Level 3:
Future Development Areas, or areas that are planned for development in the long-term, but are not currently targeted for state investments for schools, roads and other infrastructure.

Map 38
Areas for 'Future Development' represented by Level 3 Investment Areas, Strategies for State Spending.
Active Agricultural Land
Within
0.5 meter Scenario

Legend
Acres per sq ml
0 - 30
31 - 75
76 - 175
176 - 500

County Boundary
Major Road
Municipalities

Map 39
Agricultural lands (200 series) that indicate active production or cultivation.
Active Agricultural Land

Within 1.0 meter Scenario

Legend

<table>
<thead>
<tr>
<th>Acres per sq mi</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 30</td>
<td>Light Pink</td>
</tr>
<tr>
<td>31 - 75</td>
<td>Light Purple</td>
</tr>
<tr>
<td>76 - 175</td>
<td>Purple</td>
</tr>
<tr>
<td>176 - 500</td>
<td>Dark Purple</td>
</tr>
</tbody>
</table>

Source: Delaware Geographic Data Committee, 2007 Delaware Land Use and Land Cover, 2008-05-19

Map 40

Agricultural lands (200 series) that indicate active production or cultivation.
Agricultural lands (200 series) that indicate active production or cultivation.
State Parks (representing Tourism) in Delaware.
Map 43
Sites on the National Historic Register.
State Historic Sites

Legend
Historic Sites
Sites per sq mi
- 1
- 2 - 4
- 5 - 10
- 11 - 60

County Boundary
Major Road
Municipalities

Map 44
State Historic Sites within 0.5 meter scenario.
State Historic Sites

Within 1.0 meter Scenario

Legend
Historic Sites
Sites per sq mi
- 1
- 2 - 4
- 5 - 10
- 11 - 60

County Boundary
Major Road
Municipalities

Map 45
State Historic Sites within 1.0 meter scenario.

Source: Delaware State Historic Preservation Office, GIS inventory, unpublished.
State Historic Sites

Within 1.5 meter Scenario

Legend
Historic Sites
Sites per sq mi

- 1
- 2 - 4
- 5 - 10
- 11 - 60

County Boundary
Major Road
Municipalities

Source: Delaware State Historic Preservation Office, CRIS Inventory, unpublished.

Map 46
State Historic Sites within 1.5 meter scenario.
Public Safety and Infrastructure
Map 47
Structures for the impounding, diversion, or exclusion of water.
Dams & Dikes
Within 1.0 meter Scenario

Legend
Dams & Dikes
1.0 m SLR Scenario
County Boundary
Major Road
Municipalities

Map 48
Structures for the impounding, diversion, or exclusion of water.

Source: DNREC - Dam Safety Program, Dams and Dikes of Delaware, unpublished
Map 49
Structures for the impounding, diversion, or exclusion of water.
Emergency Services
Fire and EMS

Legend
- EMS Stations
- Fire Stations

within
- 0.5 m SLR Scenario
- 1.0 m SLR Scenario
- 1.5 m SLR Scenario
- Outside Scenarios

County Boundary

Major Road

Municipalities

Source: TechniGraphics, Inc., Delaware Fire Stations, 2008 Q1, 2008-04-02
TechniGraphics, Inc., Delaware Emergency Medical Services Q409, 2008-04-02

Map 50
Fire Stations, Ambulance and paramedic stations.
Emergency Services
Police Stations

Legend
- Police Stations
  within
- 0.5 m SLR Scenario
- 1.0 m SLR Scenario
- 1.5 m SLR Scenario
- Outside Scenarios
- County Boundary
- Major Road
- Municipalities

Map 91
Police Stations.

Source: DHS (Technographix), Delaware Law Enforcement 2009 Q4, 20091218
Emergency Services EOCs and 911 Centers

Legend
- Emergency Operations Centers
- 911 Centers within
  - 0.5 m SLR Scenario
  - 1.0 m SLR Scenario
  - 1.5 m SLR Scenario
- Outside Scenarios
- County Boundary
- Major Road
- Municipalities

Source: DEMA, EOC shapefile, 2011-04-03 [edit by Delaware Coastal Programs]

Map 52
Emergency Operations Centers and 911 Answering Points
Evacuation Routes
Within
0.5 meter Scenario

Legend
Routes within

- - 0.5 m SLR Scenario
  • County Boundary
  — Major Road
  □ Municipalities

Map 53
Routes specifically identified by DelDOT as evacuation routes. In emergency situations, other roads, lacking this designation, may serve the same function.
Evacuation Routes
Within
1.0 meter Scenario

Legend
Routes within
1.0 m SLR Scenario
County Boundary
Major Road
Municipalities

Map 54
Routes specifically identified by DelDOT as evacuation routes. In emergency situations, other roads, lacking this designation, may serve the same function.
Map 55

Evacuation Routes

Within 1.5 meter Scenario

Legend

Routes within

1.5 m SLR Scenario

County Boundary

Major Road

Municipalities

Routes specifically identified by DelDOT as evacuation routes. In emergency situations other roads, lacking this designation, may serve the same function.
DART Bus Routes
Within
0.5 meter Scenario

Legend
Routes within

0.5 m SLR Scenario
County Boundary
Bus Routes
Municipalities

Map 56
DART Bus Routes.
DART Bus Routes
Within
1.5 meter Scenario

Legend
Routes within

1.5 m SLR Scenario
County Boundary
Bus Routes
Municipalities

Map 56
DART Bus Routes.

Source: DelDOT - DART, DTG TRAPESI
Routes and Stops, 2010/10/01
Bus Stops in New Castle and Sussex Counties (none affected in Kent).
Railroads
Within
1.0 meter Scenario

Legend
Railroads within
- 1.0 m SLR Scenario
- County Boundary
- Major Railroad
- Municipalities

Map 61
Railroads

Source: USGS, 7.5 minute Digital Line Graphs: Rail, 20100930.
Map 63
Publicly accessible boat ramps and launches.
Roads
Within
1.0 meter Scenario

Legend
Roads within

1.0 m SLR Scenario
County Boundary
Major Road
Municipalities

Map 65
Roads and Bridges.
Map 66
Roads and Bridges
Septic Systems

Legend
Septic Systems per sq mi
- 1 - 25
- 26 - 50
- 51 - 100
- 101 - 850

County Boundary
Major Road
Municipalities

Map 68
Septic Systems.

Source: DNREC, Delaware Septic Systems (last update 20101123), unpublished
Septic Systems

Within 1.5 meter Scenario

Legend
Septic Systems per sq ml
1 - 25
26 - 50
51 - 100
101 - 850
County Boundary
Major Road
Municipalities

Source: DNREC, Delaware Septic Systems (last update 20101123), unpublished
Map 70
Sewer pumping stations.
Sewer Pumping Stations

Within 1.0 meter Scenario

Legend
Stations
Sites per sq mi
1 - 2
3 - 4
5 - 8
9 - 12
County Boundary
Major Road
Municipalities

Map 71
Sewer pumping stations.
Sewer Pumping Stations

Legend
Stations
Sites per sq mi

- 1 - 2
- 3 - 4
- 5 - 8
- 9 - 12

County Boundary
Major Road
Municipalities

Map 72
Sewer pumping stations.
Waste Water Facilities
(Publicly Owned)

Legend
Facilities within
- **0.5 m SLR Scenario**
- **1.0 m SLR Scenario**
- **1.5 m SLR Scenario**
- **Outside Scenarios**
- **County Boundary**
- **Major Road**
- **Municipalities**

Map 73
Wastewater facilities owned by Public Entities.
Map 74
Wells supplying water for industrial, agricultural, and Public Utilities.
Delaware Sea Level Rise Vulnerability Assessment

Map 75
Wells that serve individual residences.
Domestic Wells

Within 1.0 meter Scenario

Legend
Domestic Wells per sq mi
- < 25
- 25 - 125
- 125 - 300
- 300 - 625

County Boundary
Major Road
Municipalities

Map 76
Wells that serve individual residences.
Map 77
Wells that serve individual residences.
Map 78
Vacant, abandoned or underutilized properties which may be contaminated.
Landfills operated for public or private use by corporations, municipalities or individuals. Includes active and closed landfills.
Map #1
Sites with current or former leaking underground storage tanks as listed with DNREC.
Map 82

Sites with underground storage tanks as listed by DNREC.
Sites with underground storage tanks as listed by DNREC.
Map 85

SIRS Contaminated Sites

Within 0.5 meter Scenario

Legend
SIRS Sites
Acres per sq mi
1 - 45
46 - 150
151 - 370
371 - 640

County Boundary
Major Road
Municipalities

Source: DNREC - SIRB, Site Investigation and Remediation Database, unpublished.

Sites listed by the Site Investigation and Restoration Section of DNREC for current or former contamination.
Sites listed by the Site Investigation and Restoration Section of DNREC for current or former contamination.
Map 87
Sites listed by the Site Investigation and Restoration Section of DNREC for current or former contamination.
Colophon

All maps are originally produced using ArcGIS 10. Map layouts are exported to PNG at 300 dpi. Layouts are designed at 11×17 inches, however, they will be legible if printed “shrink-to-fit” at 8 ½ × 11 inches.
Delaware Sea Level Rise Advisory Committee

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